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Postia stellifera sp. nov., a stipitate and terrestrial polypore from Malaysia

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Abstract — *Postia stellifera* sp. nov. from Malaysia is described. This fungus is characterized by the distinctly stipitate basidiomata, terrestrial habit, and verrucose chlamydospores both in the context and in culture. Its macromorphology resembles that of *Albatrellus,* but phylogenetic analysis based on LSU places it within a clade comprising *Postia*, *Amylocystis,* and *Jahnoporus* where all species have a white and fleshy to soft corky context and monomitic hyphal system with clamped generative hyphae. Most sequences showing high homology with *P. stellifera* represent brown rot polypores.

Key words —*Fomitopsidaceae*, *Oligoporus,* phylogeny, *Polyporaceae*, taxonomy

Introduction

Postia Fr. (*Fomitopsidaceae*, *Polyporales*) is typified by *Polyporus lacteus* Fr. [lectotypified by Donk (1960); = *Postia tephroleuca* (Fr.) Jülich]. The genus is characterized by resupinate to sessile basidiomata with a fleshy context in fresh condition, a monomitic hyphal system with clamped generative hyphae, and causing a brown rot. A few species such as *P. ceriflua* (Berk. & M.A. Curtis) Jülich, *P. folliculocystidiata* (Kotl. & Vampola) Niemelä & Vampola, and *P. subundosa* Y.L. Wei & Y.C. Dai occasionally produce substipitate or pendent

basidiomata (Ryvarden & Gilbertson 1994, Wei & Dai 2006), but so far, species with terrestrial and distinctly stipitate basidiomata are unknown in the genus.

Oligoporus Bref. has been used for the same group of fungi (Ryvarden 1991), but *Postia* was published prior to *Oligoporus* and has been widely accepted (Buchanan & Ryvarden 2000, Dai et al. 2004, Dai et al. 2007, Niemelä et al. 2001, Rajchenberg 2006).

Tyromyces P. Karst. (type: *Tyromyces chioneus* (Fr.) P. Karst.) is morphologically similar to *Postia*, and many species now accommodated in *Postia* were once placed in *Tyromyces* (Lowe 1975, Ryvarden 1978). *Tyromyces* has been restricted to species producing a white rot, however. Phylogenetic studies also suggest that *Tyromyces* is phylogenetically distinct from *Postia* (Binder et al. 2005, Yao et al. 1999).

During field trips in Peninsular Malaysia in 2002 and 2007, we collected a polypore with distinctly stipitate and terrestrial basidiomata, a white and fleshy context, oblong ellipsoid basidiospores, and verrucose chlamydospores in the context. Its mycelium in pure culture did not react with 1-naphthol, suggesting a lack of laccase and, consequently, that it is not a white rot fungus (Käärik 1965).

Within the genera of polypores (Ryvarden 1991), the micro-morphological and physiological features of this species would point toward *Postia*. However, the terrestrial and stipitate habit together with the verrucose chlamydospores deviates from *Postia* as currently circumscribed.

In this study, we examined the phylogenetic position of the present fungus in relation to several *Postia* spp. and related polypores. After detailed morphological examinations and other characteristics, we describe it as a new species.

Materials and methods

Sequencing and phylogenetic analysis

Five fungal isolates including *Postia* spp. (Table 1) were grown and harvested according to Ota & Hattori (2008). DNA was extracted using a DNeasy Plant Mini Kit (Qiagen, Valencia, CA, USA). Nuclear ribosomal LSU sequences were generated following the methods of Ota & Hattori (2008) or Sotome et al. (2008). DNA sequences were determined using a BigDye Terminator 3.1 Cycle Sequencing Kit (Applied Biosystems, Foster City, CA, USA) with the ABI 3100 DNA sequencer (Applied Biosystems). Sequences were edited with Vector NTI advance 9.0 (InforMax, Frederick, MD, USA) then submitted to GenBank (accession numbers AB569119-569123, Table 1). Twelve additional nrLSU sequences were retrieved from GenBank. *Lentinus tigrinus* (Bull.) Fr. and *Polyporus squamosus* (Huds.) Fr. were used as outgroups because they belong to *Polyporaceae* but are outside of the family *Fomitopsidaceae* that accommodates *Postia* species and their allies. The sequences were aligned using Clustal X (Thompson et al. 1997). The alignment of the nrLSU regions was deposited in TreeBase (accession

Table 1. List .of species, strains, and voucher specimens newly sequenced in this study and GenBank accession numbers for the LSU sequences.

Species	Strain No.	Voucher No.	Origin	Accession No.
Postia caesia	WD-1974	F-18596	Japan, Kochi	AB569119
P. caesia	WD-1976	F-18605	Japan, Kochi	AB569120
P. japonica	WD-2103	F-19345	Japan, Kyoto	AB569121
P. japonica	WD-2338	IFP Dai 8046	Japan, Ibaraki	AB569122
P. stellifera	PEN49	F-20668	Malaysia, Penang	AB569123

S10658). The data set was analyzed in PAUP* 4.0b10 (Swofford 2003). Maximum parsimony analysis was performed for the dataset with the heuristic search option with 100 random addition sequences and tree bisection and reconstruction (TBR) as the branch-swapping algorithm. All gaps were treated as missing data. The robustness of individual branches was estimated based on 1000 bootstrap replications.

Morphological studies

Macroscopic characteristics were described based on fresh and dried specimens. Microscopic characteristics based on dried specimens were determined by examining free-hand sections mounted in Melzer's reagent or in 5% (w/v) KOH solution. A non-dextrinoid and non-amyloid reaction was described as IKI–. The following abbreviations are used in the text: L, mean spore length; W, mean width; r, the ratio of length/width of a basidiospore; R, mean of r. The term (n = x/y) means x measurements of basidiospores from y specimens. The examined specimens were deposited in TFM or KEP.

Cultural characteristics were studied on potato dextrose agar plates at 25°C and described according to Nobles (1965) and Stalpers (1978). Presence of extracellular oxidase was tested with 1-naphthol ethanol solution and tyrosine ethanol suspension (Käärik 1965). The examined culture was deposited in the culture bank of Forestry and Forest Products Research Institute (FFPRI), Tsukuba, Japan.

Results

Phylogenetic analysis

A preliminary search using the blast option showed homology with several brown rot polypores. The phylogenetic affinities of the present fungus were estimated using 20 LSU sequences, with an aligned length of 751 base pairs. Fifty positions were variable but uninformative and 86 positions parsimony were informative. Parsimony analysis of the nrLSU data set yielded two most parsimonious trees, 269 steps in length (CI = 0.58, RI = 0.68, RC = 0.40) (Fig. 1).

The present fungus was placed within a weakly supported clade that includes the species *Postia caesia* (Schrad.) P. Karst., *P. guttulata* (Peck) Jülich, *P. japonica* Y.C. Dai & T. Hatt. and *P. rennyi* (Berk. & Broome) Rajchenb. This clade is included in a larger one (*Postia* s.l. clade) that includes *Amylocystis*

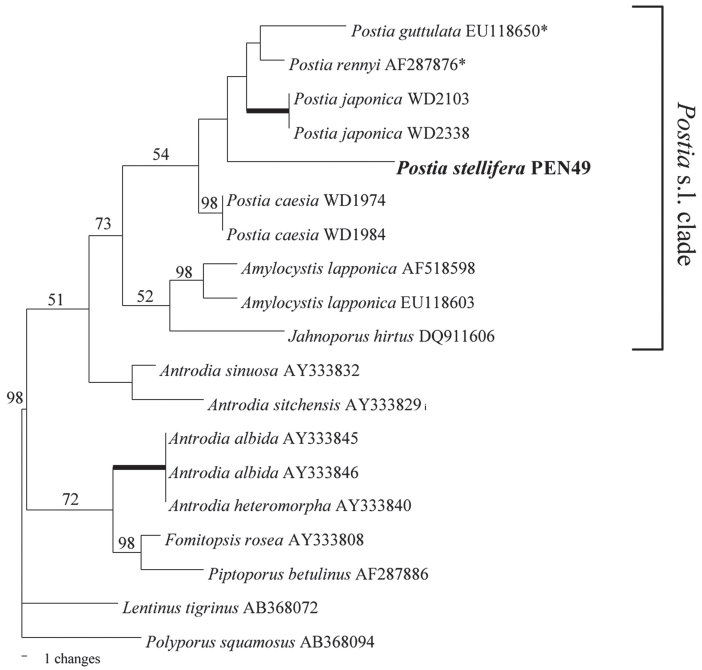

Fig. 1. One of the two most parsimonious trees obtained from heuristic searches based on LSU sequence dataset of *Postia stellifera* and its related species. Bootstrap support values above 50% are indicated at the nodes. Taxa marked with * were originally submitted to GenBank as *Oligoporus*.

lapponica (Romell) Bondartsev & Singer ex Singer, and *Jahnoporus hirtus* (Cooke) Nuss. The cultural characteristics of *J. hirtus* are still not fully known, but other members of this clade are brown rot polypores with a monomitic hyphal system.

Description

Postia stellifera T. Hatt. & Sotome, **sp. nov.** Figs 2, 3

MycoBank 518628

Basidiocarpia annua, stipitata, terrestria. Pilei circulares, subtomentosi, brunneoli. Contextus carnosus, albus. Facies pororum alba, pori angulares, (1–)2–3 per mm. Stipes centrales, albi. Systema hypharum monomiticum, hyphae generativae hyalinae, fibulatae, hyphae in contextu inflatae. Basidiosporae oblongae, hyalinae, haud dextrinoideae, 4.5–5.5 × 1.8–2.3 µm. Chlamydosporae verrucosae, hyalinae vel luteolae, 7.5–12.5 × 6.8–10.8 µm.

Holotypus: **Malaysia.** *Penang, Gertak Saggul, ad terram in silva, 26.XII.2002, leg. T. Hattori & S. Baharuddin (TFM F-20668).*

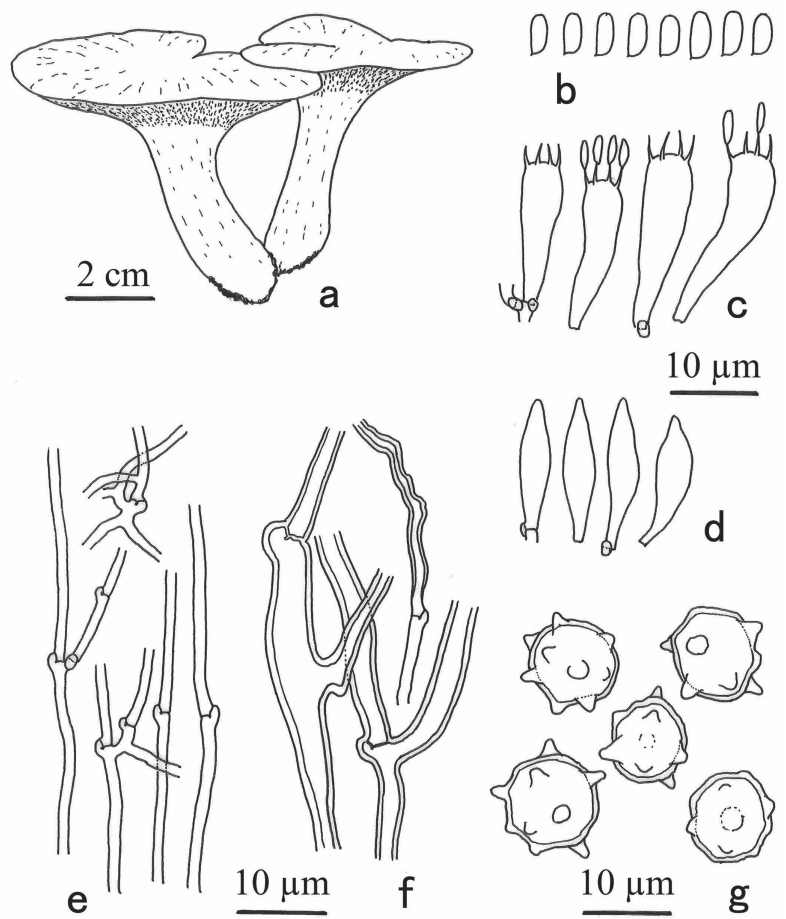

Fig. 2. Structures of *Postia stellifera* (from holotype).
—a: Basidiocarps. —b: Basidiospores. —c: Basidia. —d: Cystidioles. —e: Chlamydospores from context. —f: Generative hyphae from trama. —g: Generative hyphae from context.

Etymology: Latin, *stellifera* = with stars, referring to the star-shaped chlamydospores seen both in the context of the basidiomata and in the culture.

Basidiomata annual, centrally stipitate, terrestrial. Pilei circular, applanate to convex, pileus surface subtomentose to pubescent, azonate, light brown to light grayish brown, whitish near the margin, pileus margin thin and acute, entire, up to 7 cm in diam. Pore surface white to cream in fresh condition drying

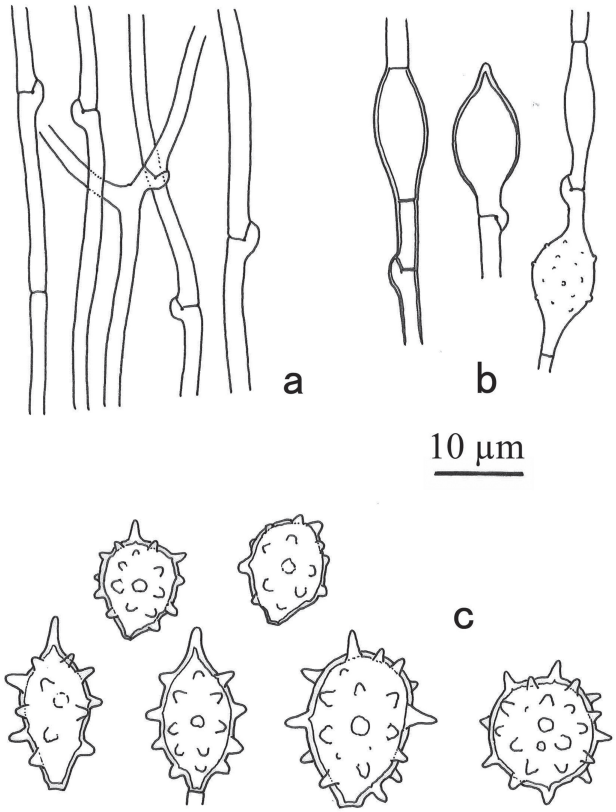

Fig. 3. Structures of *Postia stellifera* (from ex-type culture).
—a: Generative hyphae from advancing zone. —b: Young chlamydospores.
—c: Mature chlamydospores.

sordid white to grayish; pores angular, (1–)2–3 per mm, dissepiments thin, entire, with conspicuous hyphal pegs near the pore mouth. Context fleshy in fresh condition, soft and flexible in dried condition, spongy near the pileus surface, dense near the tubes; grayish brown near the pileus surface, partly light brown near the tubes, otherwise whitish to pale orange, up to 7 mm thick. Tubes whitish, fleshy in fresh condition, drying more or less brittle, decurrent on stipe, up to 5 mm deep. Stipes cylindrical, stipe surface pubescent, white in fresh condition, light brown to grayish in dried condition, up to 5 cm long and 1.5 cm wide.

Hyphal system monomitic both in context and trama. Contextual generative hyphae with clamp-connections, thin- to thick-walled with a distinct lumen,

mostly sinuous, occasionally branched, hyaline, IKI–, inflated hyphae abundant, 2–15 µm wide. Chlamydospores scattered to abundant in the context, verrucose, appendages up to 2.5 µm long, hyaline to yellow, 7.5–12.5 × 6.8–10.8 µm (excluding appendages). Tramal generative hyphae with clamp-connections, thin-walled, straight or sinuous, sparsely to conspicuously branched, hyaline, IKI–, 1.8–5 µm wide. Cystidioles present in hymenium, fusoid to mammillate, smooth, thin-walled, 14–22 × 4–5.5 µm. Basidia clavate, 4-sterigmate, with a basal clamp, 18–25 × 5–7 µm. Basidiospores oblong ellipsoid to short cylindrical, thin-walled, smooth, hyaline, IKI–, 4.5–5.5 × 1.8–2.3 µm, L = 5.07 µm, W = 2.86 µm, r = 2.21–2.78, R = 2.44 (n = 23/1).

Cultural characteristics — Growth slow, 1.2–1.4 mm/day, plates covered in 6 weeks. Advancing zone bayed, appressed, white. Mat at first white, aerial mycelium woolly to flat, becoming cream to light brown from the center. Reverse unchanged. Odor indistinctive. Hymenophore development not seen within 6 weeks. Generative hyphae from the advancing zone thin-walled, moderately branched, hyaline, 1.5–4 µm wide, with clamp-connections. Generative hyphae from aerial mycelium and submerged mycelium as in advancing zone. Chlamydospores abundant, produced intercalary or on the apex of hyphae, at first fusoid, thin-walled, smooth and hyaline, later ellipsoid to subglobose, thick-walled, distinctly verrucose to spinose, appendages up to 4 µm long, hyaline to yellow, 7–20 x 6–12 µm (excluding appendages).

Extracellular oxidase activities — 1-naphthol, –; tyrosine, +.

Species code — 2, 3, 7, 34, 36, 38, 46, 56 (Nobles 1965); 2, 9, 13, 15, 22, 30, 31, 39, 45, 52, (53), 85, 91 (Stalpers 1978).

Examined culture — PEN49 (ex-type strain, isolated from TFM F-20668).

Type of rot — unknown, but probably brown rot.

Other specimen examined — Malaysia. Perak, Taman Negara Royal Belum, alt. 259 m, on soil, 18 June 2007, leg. BK Thi (KEP FRIM4583).

Discussion

Within the genera of polypores (Ryvarden 1991), the micro-morphological and physiological (type of rot — viz. in all probability a brown rot) features of this species would point toward *Postia* as a possible genus. In addition to the decay type, the following characteristics are common to the present fungus, *Postia* and its allies: white and fleshy to soft corky context, poroid hymenophore, monomitic hyphal system, generative hyphae with clamp-connections, and smooth basidiospores without distinct reactions in iodine reagents.

Our phylogenetic study also indicates that this fungus is related to several *Postia* species, *Amylocystis lapponica,* and *Jahnoporus hirtus*. However, the phylogenetic position of *P. stellifera* within a hypothetic *Postia* s.l. clade is still

unclear, because sequences of many *Postia*, including the type species, are still unavailable and the clade consisting of *Postia* species is weakly supported.

One of the very distinctive characteristics of *P. stellifera* is the presence of a well-developed stipe with a terrestrial habit, a feature hitherto unknown in *Postia* and other related genera. Several polypore genera accommodate only stipitate and terrestrial species such as *Albatrellus* Gray, *Coltricia* S.F. Gray, *Boletopsis* Fayod, *Corneroporus* T. Hatt., *Diacanthodes* Singer and *Polyporoletus* Snell in addition to *Jahnoporus*. However, a few genera include both lignicolous and terrestrial species, e.g., *Microporellus* Murrill with *M. clemensiae* (Murrill) Ryvarden and *M. inusitatus* (Lloyd) Corner both terrestrial versus *M. grandiporus* Corner and *M. peninsularis* (Corner) Decock, both lignicolous (Corner 1987, Decock 2001). *Phylloporia* Murrill and *Amauroderma* Murrill also accommodate both lignicolous and terrestrial species.

Another distinctive characteristic of *P. stellifera* is the presence of verrucose chlamydospores in the context, also present in culture on artificial media. Chlamydospores are present in the context of several *Postia* species such as *P. ptychogaster* (F. Ludw.) Vesterh., *P. rennyi* and *P. brunnea* Rajchenb. & P.K. Buchanan (Rajchenberg & Buchanan 1996, Ryvarden & Gilbertson 1994), and many produce subglobose to ellipsoid chlamydospores in cultures, but they are always smooth.

After intensive examination of the oxidative reactions of wood-decay fungi, Käärik (1965) listed the following 3 species that did not have laccase but had tyrosinase as in *P. stellifera*: *Lentinus lepideus* (Fr.) Fr. [≡ *Neolentinus lepideus* (Fr.) Redhead & Ginns], *Merulius lacrymans* (Wulfen) Schumach. [≡ *Serpula lacrymans* (Wulfen) J. Schröt.], and *Trechispora brinkmannii* (Bres.) D.P. Rogers & H.S. Jacks. [≡ *Sistotrema brinkmannii* (Bres.) J. Erikss.]. Like these three species, *P. stellifera* is in all probability also a brown rot fungus.

Amylocystis lapponica is characterized by amyloid cystidia and hyphae but is otherwise similar to *Postia* with monomitic hyphal system and a rot (Ryvarden & Gilbertson 1993). Nobles (1958) placed *J. hirtus* in the group positive for extracellular oxidases on the basis of the Bavendamm reaction and application of ethanol gum guaiacum. Chang (1994) also concluded that this is a white rot fungus using Bavendamm reaction. However, these methods cannot differentiate laccase and tyrosinase (Harkin et al. 1974) and are unable to evaluate the decay type.

Jahnoporus is the only genus to accommodate a stipitate and terrestrial species among the allied genera of *P. stellifera* and is often placed in *Albatrellaceae* (Kirk et al. 2008). Another distinctive characteristic of *Jahnoporus* is the large and spindle-shaped basidiospores that are unknown both in phylogenetically related genera and the morphologically similar genus *Albatrellus* (Gilbertson & Ryvarden 1986). We prefer not to put *P. stellifera* into *Jahnoporus* because

of the difference in basidiospore morphology and the presence of verrucose chlamydospores in the context of the former. The phylogenetic position of another species of *Jahnoporus, J. pekingensis* (J.D. Zhao & L.W. Xu) Y.C. Dai, is still unknown, but it also has large and more or less fusiform basidiospores that are different from those of *P. stellifera* (Dai 2003).

The present fungus may be easily mistaken for an *Albatrellus* species because of the terrestrial habit and macro-morphology, but this genus is hitherto unknown from lowland rainforest of Southeast Asia, although there are a few reports of it from the highlands of Malaysia and Papua New Guinea (Corner 1989, Quanten 1997). Most of the *Albatrellus* species are considered to be mycorrhizal and difficult to cultivate on artificial media and/or their growth is much slower (18.3-33.0 mm/8-wks on PDA, Akama et al. 2008). Most of the *Albatrellus* species have short ellipsoid to subglobose basidiospores (Gilbertson & Ryvarden 1986; Ryvarden & Gilbertson 1993) while our species has long ellipsoid basidiospores. Additionally, verrucose chlamydospores are unknown in *Albatrellus*.

Most *Albatrellus* species are included in the russuloid clade, except *A. syringae* (Parmasto) Pouzar and *A. peckianus* (Cooke) Niemelä, which are placed in 'the residual polyporoid clade' where other members of this clade are lignicolous and associated with a white rot (Binder et al. 2005, Bruns et al. 1998, Cui et al. 2008, Ryman et al. 2003). In addition to their phylogenetic status, the cultural characteristics suggest that *A. syringae* is possibly a white rot fungus (Niemelä 1970, Stalpers 1992), and Ryman et al. (2003) implied that it should be excluded from *Albatrellus*. *Albatrellus peckianus,* which has been reported to be attached to buried wood of *Fagus* and *Tilia* (Lowe 1942, Overholts 1953), is also possibly a saprobe. As in *A. syringae* and *A. peckianus*, *P. stellifera* is phylogenetically isolated from *Albatrellus* sensu stricto, despite their macro-morphological similarity.

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